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PRELIMINARY CONCEPT FOR SAFEGUARDING SPENT FUEL ENCAPSULATION PLANT IN OLKILUOTO, FINLAND

Phase III report on Task FIN A 1184 of the Finnish support program to IAEA Safeguards

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Abstract

The Encapsulation Plant, a part of the final disposal facility for spent fuel, will be located at Olkiluoto, at location close to the Nuclear Power Station. The company engaged in the final disposal in Finland has by now prepared a working report that describes the design of the Encapsulation Plant with the level of details that makes possible the development of a preliminary safeguards concept. The concept developed under this task is aimed at enabling the IAEA to implement a cost-effective safeguards approach for this new type of facility. Significant effort was invested by an informal team to understand the nature of the IAEA integrated safeguards and, particularly, the role of Additional Protocol measures in safeguarding the encapsulation process as part of the final disposal. A brief assessment was made regarding the technical feasibility of the proposed safeguards concept. Also consideration was given as to the further work required to for its application.

Contents

1 Introduction

The Finnish Support Programme Task FIN A 1184 concerning “Safeguards for Finnish Spent Fuel Conditioning Plant” has through the work done during the Phase I and II advanced to the point to develop a preliminary safeguards concept.

Phase I of the Task provided information about the back end of the fuel cycle in Finland including interim storage, encapsulation plant and final repository. Description of the preliminary design of the encapsulation plant was provided [1]. The results of Phase II were discussed in a workshop in Helsinki, Finland, 12–20 December 2000 [2].

In the Annual Support Programme Review Meeting, March 2001, it was agreed to develop the preliminary safeguards concept as the Phase III activity and to consider the Task thereby as completed. In subsequent discussion of the results cooperation with the IAEA and the Euratom is very important, particularly because no implementation experience has been gained yet of safeguarding the final disposal of spent fuel.

The decision-making process on the final disposal of spent fuel in the Finnish bedrock consisted of several stages, with participation of the citizens, municipalities and state authorities. Several opportunities were given to become acquainted with various phases of the project and to express opinions and articulate concerns. The governmental and parliamentary policy level decisions have been taken by May 2001. The final disposal site has been selected and its location identified close to the Olkiluoto NPP in Eurajoki.

The overall time schedule for the Operator’s (Posiva Oy) disposal plan foresees now further detailed site-specific investigations and design of the site layout, including buildings and the relevant services. Two optional locations in Olkiluoto are considered. The encapsulation plant is attached to the KPA-store or constructed as an independent facility an adjacent site. The preliminary design of the encapsulation plant itself is available in the form of working reports [3], [4]. The one describing the Encapsulation Plant as an independent facility is used here as primary reference. The results of the SAGOR activities are used as further general reference.

The State of Finland, and particularly the competent authorities, Ministry of Trade and Industry and STUK responsible for safety and security are obliged to present to the designer the requirements that would appropriately cover also those pertinent to safeguards. Further to this, the development of the preliminary concept should provide guidance as to the general design for the overall safeguards system so that the needs of all parties will be timely and appropriately addressed.

It is important to note that the application and implementation of safeguards measures associated with the final disposal will begin already during the planning and pre-operational phase. The constructions of the rock characterization facility and site confirmation investigations are planned to commence already during 2004 and the construction of the encapsulation plant is planned to begin 2010. In order to ensure cost-effectiveness of safeguards for the back end of the nuclear fuel cycle timely engagement of all relevant parties in design, planning, development of approaches, methods and techniques is essential.

This report describes the preliminary safeguards concept for the Encapsulation Plant as part of the final disposal of spent fuel. The concept is aimed at enabling the IAEA to develop and implement a cost-effective safeguards approach for this new type of facility. The report reflects the results of an informal team that worked in close cooperation with the authority and the designer. Significant effort was invested to understand the nature of the IAEA integrated safeguards and, particularly, the role of Additional Protocol measures in safeguarding the encapsulation process as part of the final disposal. It became evident that safeguards of the encapsulation process will play key role in the efforts to develop the required management confidence that all spent fuel subject to final disposal is accurately accounted for and that the knowledge is maintained by all Parties in a credible manner.

The concept developed under this support program task is not intended to become a safeguards approach and procedure that are the responsibility of the IAEA. It is also not about the procedures that the Euratom may consider using in order to satisfy its institutional requirements.

An annex is included to the report describing the results of a brief assessment regarding the technical feasibility of the described preliminary safeguards concept and the further work that is necessary to apply the proposed concept.

Before describing the final disposal and the safeguards concept some basic assumptions are elaborated. These include changing threat scenario and its impact, the idea of integrated safeguards and enhanced role of FIN-SSAC as well as areas for increased co-operation in implementation.

2 Coping with changing threat

2.1 Deterrence

The technical objective of safeguards is identified in the comprehensive Safeguards Agreements [5] as timely detection of diversion of significant quantities of nuclear material, and deterrence of such diversion by the risk of early detection.

Deterrence can be understood as an impact on a State or any other actor contemplating to conduct an unlawful act. It is a desired preventive consequence of credible application of all available measures and effective implementation of the safeguards system functions.

Until early 90's the purpose of safeguards, from operational point of view, was the prevention of diversion of the declared nuclear material from declared facilities and activities. Implementation effort was focused on accountancy verification of declared nuclear material and use of containment and surveillance measures to maintain the continuity of that knowledge. Administrative efficiency was the desired goal of the organization activity. IAEA safeguards was assessed by the Member States to be able to meet this technical objective, namely to verify the correctness of the declarations.

The other 'technical' objective, namely the deterrence of diversion by the risk of early detection was taken into account in establishing the approaches and in the implementation. It was an element introduced into the system when assessing the credibility of the approaches and developing the procedures for the accountancy verification at declared facilities.

However, the deterrence may not have played explicit enough role in negotiations, in establishment of initial inventories and in establishing routine operational activities as well as in analyzing and evaluating information. The risk of early detection of indications or indicators by the IAEA of possible undeclared nuclear materials and activities was limited, in any case, very much dependent of information from other States. The completeness of the declarations was not assured through operative activity.

In order to secure the credibility of the international safeguards the completeness of the declarations made by States must be ensured in addition to verification of their correctness. Access to additional information and right of access to any place at any time appeared necessary for the IAEA safeguards system to be able to assure the completeness and full compliance with the terms of the safeguards Agreement. The Additional Protocol to the Safeguards Agreement [6] offers legally binding provisions to bring that effect.

Direct and prompt access to UN Security Council is now available to cope timely with any possible non-compliance by a State with its Non-Proliferation Treaty obligations. Further to this, Member States of the IAEA are expected to co-operate in good faith so as to ensure that the IAEA safeguards will have required resources and become truly cost-effective.

2.2 Security and safeguards

Since 11 of September 2001 also nuclear terrorism shall be considered as a credible threat. Sub-national groups or individuals supported by international networks may want, in an unpredictable moment, to cause unacceptable and severe consequences to human societies and to the environment. Society requires security relevance also from safeguards.

The nature of the challenge is very different from the one addressed during the cold war conditions. The perceived adversary does not necessarily have an address to contact, no clear frontlines can be identified to confront, no assets to retaliate, apparently no direct possibilities to influence the motivations. The means and ways selected to cause mass destruction are mostly unpredictable.

National authorities in co-operation with international competent authorities are responsible for security and must respond also to these kinds of threats. The Non-Proliferation Treaty regime and particularly the international IAEA safeguards system supported by regional and national systems shall respond to this changing security environment. Functional responsibilities shall be implemented in a manner that confidence will be built on credible grounds and that implementation will have more direct relevance to security.

In Finland the non-proliferation safeguards has always been considered as an important element in confidence building and security. Data and information generated by different activity may prove to have relevance in different context, safety, security or safeguards. Therefore, and in order to ensure timely detection and action, co-operation in implementation, analysis and evaluation of the findings is essential. IAEA integrated safeguards are expected to play increased role also for national security.

3 Integrated safeguards implementation process

3.1 General view to integrated safeguards

IAEA, the Secretariat, is trusted by the Member States to apply all available measures so that there is credible assurance of the absence of undeclared nuclear activities and materials and of the absence of diversion of declared nuclear material from peaceful purposes to nuclear weapons or to other nuclear explosive devices or to purposes unknown.

Integrated safeguards can be understood as an optimal combination of the accountancy verification measures that are supported by containment and surveillance and the complementary access measures assuring the completeness of the information provided, the absence of undeclared nuclear materials and activities.

The IAEA carries out its inspections and complementary activities as well as State-level analysis and evaluations in order to draw conclusions about compliance by Finland of its safeguards obligations. These activities and assessments are based on the declarations and clarifications provided by Finland and Euratom, as applicable, as well as on the results of IAEA own activity and information obtained from open sources and other parties.

The IAEA will report the conclusions to its Governing Bodies, to the Board of Governors and to the General Conference. The IAEA keeps the UN Security Council informed of the safeguards situation and, in case further enforcement is required, provides also formal reports to the Security Council.

The analysis and State evaluation is not limited to serve the purposes of annual reporting but is a continuous process directing the ongoing implementation of the measures. IAEA safeguards need to provide for early detection and timely respond. This is an important characteristic when safeguarding a continuous process like the encapsulation of spent fuel and its final disposal.

3.2 Additional protocol

Implementation of the ‘traditional’ safeguards measures [5] and the analysis and evaluation activities carried out by the IAEA has enabled it, thus far, to draw conclusions that the nuclear material placed by Finland under the IAEA safeguards remained in peaceful nuclear activities or was otherwise adequately accounted for.

Finland, as all other States, are obliged to notify *all* nuclear material subject to the IAEA safeguards. However, the IAEA was not explicitly required to ensure through any legally binding particular procedures and operations that this was really the case. Therefore the safeguards operations and evaluations were focused to the declared nuclear material only.

The Additional Protocol was adopted as a formal part of the IAEA safeguards system in May 1997 [6]. When it is in force and adequately implemented, it enables the Member States of IAEA to assure that Finland has really placed all nuclear material to IAEA safeguards. The Additional Protocol is expected to be in force in the European Union, including Finland, by the end of 2002.

Within 180 days from the day of enforcement Finland and the Euratom will provide IAEA with the additional information. The IAEA will be then in a position to begin with the implementation of all measures of its strengthened system, including those of the Additional Protocol.

The FIN-SSAC and the Euratom, respectively, will provide timely the IAEA with the additional information that is required by the Additional Protocol about its nuclear program, including related R&D activities. Such information is given in the form of the design information, the nuclear material accountancy reports and other notifications informing about the nuclear activities at facilities in Finland.

It is understood that during a reasonable period of time, about 2–3 years, the IAEA should be in a position to draw conclusion that all nuclear material subject to its strengthened safeguards has been placed under safeguards by Finland and that it remained in peaceful nuclear activities or was otherwise adequately accounted for. This would mean that latest by the year 2006 the integrated IAEA safeguards could be in action in Finland.

It is important to note that the information provided by Finland and Euratom is taken as declarations and are understood to be legally binding. They form the basis for the IAEA to implement its State-level approaches and to carry out State evaluation activity to assess the compliance of Finland with its obligations under the Safeguards Agreement and the Additional Protocol. Successful conclusions are dependent on the performance of all Parties, FIN-SSAC, Euratom, IAEA and other States.

The complementary measures of the Additional Protocol are expected to play central role in safeguarding the Encapsulation Plant as an integral part of the final disposal of spent fuel in Finland.

4 Roles and responsibilities in implementation

Finland takes care of the safety, security, and economical and social well-being of its citizens and the environment. Finland participates in the international society and has decided voluntarily to limit its sovereignty by signing the Treaties, the Safeguards Agreements and Protocols, thereby assigning particular functional responsibilities to institutions like the IAEA and those of the European Union. Finland, however, has not delegated the responsibility for confidence building and security.

Experience suggests that efficient and effective co-operation in safeguards cannot be created only on the basis of interpretations of the rights and obligations that are assigned to the Parties. It is understood that the genuine co-operation becomes possible when the Parties will be clearly subordinated to serve the co-operation process that is aimed at facilitating to meet the objectives and to serve the purposes of the integrated IAEA safeguards. The discussion in that case is focused on the responsibility in safeguards implementation.

4.1 Role and functional responsibilities of FIN-SSAC

4.1.1 General

During the 90's, non-proliferation has become a central security objective in the world. It is an established Finnish policy to contribute to that end in all areas. Finland has been a State party, from the beginning, to the relevant treaties, notably Nuclear Non-Proliferation Treaty (NPT), the Chemical Weapons Convention (CWC), the Biological and Toxic Weapons Convention (BTWC) as well as the Comprehensive Test Ban Treaty (CTBT). Finland contributes to international efforts in the area of the physical protection of nuclear facilities, transportation, materials and activities.

Finland is an active participant in all export control regimes, such as the Nuclear Suppliers Group (NSG), the NPT Exporters Committee (Zangger Committee), the Missile Technology Control Regime (MTCR).

The Finnish State System of Accounting for and Control of nuclear materials and activities (FIN-SSAC) is an element in the national regime and systems aimed at preventing proliferation of nuclear weapons.

In the area of the use of nuclear materials and conduct of nuclear activities in Finland the functional responsibilities within the national system are shared between by the Ministry of Trade and Industry (MTI), the Radiation and Nuclear Safety Authority (STUK) and the Operator of nuclear activities.

MTI has the overall responsibility and particular functional responsibilities on various areas, including the area of export control. STUK has the primary responsibility for controlling the use of nuclear materials in Finland. These authorities are supported by the National Board of Customs of the Ministry of the Interior, the Ministry of Defense and the Security Police.

4.1.2 STUK

STUK, as the competent authority, is assigned by law [7] to prevent proliferation of nuclear weapons from nuclear materials and nuclear activities within the territory of Finland, under its jurisdiction or under its control anywhere. In this capacity STUK is:

- Ruling, regulating and exercising control on the nuclear material activities in Finland. It is required to maintain its independence and to ensure through its own inspections that it knows with required level of accuracy and certainty what is happening and may be expected to happen in its area of responsibility in Finland;

- Enhancing the FIN-SSAC to respond to the requirements of the strengthened international IAEA safeguards; to provide required declarations and other findings so as to facilitate verification and clarification inspections and complementary access visits;

- Satisfying itself that the IAEA safeguards system as applied and implemented in Finland is providing for credible results and conclusions about the full compliance of Finland with its obligations under the Safeguards Agreement.

- Supporting, as required, the other Parties engaged in the implementation of safeguards so that they can carry out their functional responsibilities efficiently and effectively.

4.1.3 Operator

Operators are responsible to keep STUK informed about the nuclear materials and activities they are using or know about. Operators are conducting their business in a safe and physically secured manner and in compliance with the safeguards requirements. In its capacity the Operator is:

- Establishing and operating a nuclear material accountancy and control system that with the required level of accuracy keeps record on nuclear materials and activities and provides the required notifications, reports and other information to the Parties responsible for the verification function and other complementary safeguards functions;

- Establishing and maintaining conditions that are required to facilitate effective use of agreed monitoring, containment and surveillance measures;

- Facilitating access of IAEA designated inspectors and other authorized personnel to places within the facility and site to carry out their functional responsibility;

- Facilitating, on its part, clarification of any anomaly or inconsistency and shall respond to questions that are relevant to safeguards, and from its part;

- Ensuring that:
    - the implementation of safeguards is not hampering the economic and technological development or international co-operation in the field of peaceful nuclear activities;
    - the health, safety, physical protection and other security provisions as well as the rights of individual are respected, and that;
    - every precaution is taken to protect commercial, technological and industrial secrets.

One of the primary functions of FIN-SSAC is to assure that all relevant findings are notified, declared, reported or communicated otherwise to all Parties who need to know within and out of Finland. The quality of the findings and communications will be ensured so as to enable cost-effectiveness in the performance of safeguards by Euratom and IAEA functions. The relationships within the FIN-SSAC are such that the required independence of the competent authority is not at risk.

The FIN-SSAC provides a process and infrastructure that enables the competent authority STUK and the licensee, the Operator, to carry out their particular functional responsibilities efficiently and effectively. Consistent with the objectives and quality policy the functional responsibilities include those aimed at:

- ensuring conditions that at the sites, facilities and in Finland as a whole efficient and effective implementation of safeguards is possible;
- generating and communicating authentic, accurate, secured data and information;
- ensuring correspondence with the reality of the generated data and information (verification function) and coherence with the results and conclusions obtained (clarification function);
- facilitating knowledge creation and consequent decision-making and decisive action.

In addition to the above operative responsibilities the FIN-SSAC functions include measures that

are:
- ensuring clarity in the implementation responsibilities;
- providing for an adequate technological and administrative infrastructure;
- ensuring ongoing learning and improvement of resource competencies and skills;
- ensuring ongoing improvement in administrative efficiency and effectiveness.

4.2 Co-operation of FIN-SSAC, IAEA and Euratom

All Parties are obliged to ensure cost-effectiveness, to keep the frequency and intensity of activities to the minimum consistent with the objectives of safeguards. This implies that the functions of the Parties are well defined and coherent with their roles in the integrated safeguards implementation process. Such clarity makes it possible to identify and allocate the required resources and to ensure effective co-operation in implementation.

It is understood that each Party shall be able to draw its conclusions independently on the basis of premises established by it or otherwise secured by it. And that they shall be able to do it in a credible manner, without a high risk of bringing an evidence of non-objectivity or that of incompetence.

The FIN-SSAC has the technical capabilities, experience and established structures, processes and practices that warrant extensive co-operation in implementation, development and training.

Enhanced co-operation in safeguarding the Encapsulation Plant is possible. The relationships, roles and responsibilities of the Parties in integrated safeguards implementation are schematically described in Figure 1.

Further to that it is understood that the IAEA criteria shall be met in all applicable cases. However, should there be a need for Euratom to perform an additional activity in order satisfy its other institutional obligations, such situations would be addressed appropriately but separately.

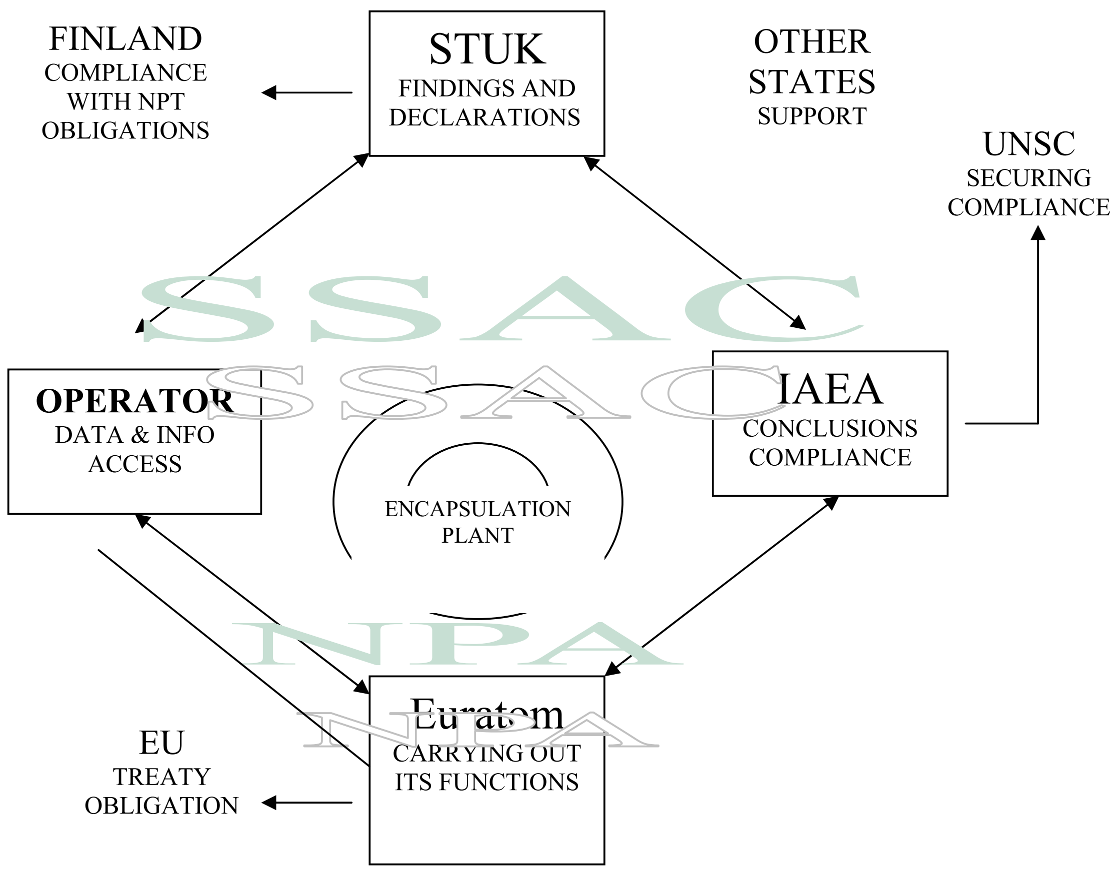

Figure 1. *Roles and functional responsibilities of the Parties in implementation of the integrated IAEA safeguards.*

Co-operation between the Parties could extend to the following areas:

1. Development and testing of implementation approaches, procedures and practices;
2. Development of sampling plans, calibration and measurement procedures;
3. Development of information technological interface and communication protocols and procedures that would facilitate authenticated data and information collection and secured transfer;
4. Performance of NDA and in-field DA measurements using common equipment;
5. Shared use of the SSAC workstations and laboratories, including joint assessment and evaluation of data and information in order to assure the quality of obtained data and information;
6. Use of monitoring equipment, seals and surveillance;
7. Conduct particular inspection activities – However, not complete inspections so as not to risk the possibility to draw conclusions independently;
8. Shared procurement of safeguards equipment;
9. Use of training facilities equipment, material and programs.

The co-operation between the Parties shall be approached pragmatically and discussed as a practical matter keeping the roles of the Parties in mind and the objectives and purposes of safeguards in sight.

In addition, the IAEA could use inspection data and information generated by the FIN-SSAC and/or the Euratom as part of the premises that the IAEA is using to draw its independent conclusions. Such data and information are hereby understood to mean the 'findings' of the SSAC and of the Euratom. It is important to note that Finland and the Euratom have established understanding about the communications with the IAEA and about the mutual exchange of data and information so as to ensure co-ordination.

The condition for the IAEA to use efficiently the services is that the FIN-SSAC and/or the Euratom are capable to produce technically valid results and that it is proven by the IAEA that such results are produced by a competent personnel and in conformity with the principles and established procedures.

4.3 Role of Euratom in integrated IAEA safeguards

The Euratom plays an instrumental role and carries out particular functional responsibilities aimed at facilitating cost-effective application of the measures and implementation of the functions of the IAEA integrated safeguards system. These particular functional responsibilities and services shall be defined in the enhanced New Partnership Agreement, to be agreed upon.

4.4 Role of IAEA

The IAEA is responsible to ensure cost-effective application of all available measures and implementation of the system functions by the Parties. The IAEA is to verify the compliance of Finland with its obligations under the safeguards Agreements, including those of the Additional Protocol.

The IAEA is responsible to perform its independent clarification and verification work, analysis and evaluation effort as well as reporting functions so that there is credible assurance of the absence of undeclared nuclear activities and materials, and the absence of diversion of declared nuclear material in Finland.

The IAEA shall carry out its clarification and verification activities and draw its conclusions in a timely manner so as to facilitate the implementation of integrated safeguards in Finland, thus facilitating the Member States of the IAEA to assess adequacy of the assurances provided by the IAEA safeguards. In case the IAEA is unable to draw confirmative conclusions it is expected to report to its governing bodies and, as appropriate, to the UN Security Council.

In the implementation of safeguards the IAEA shall take into account the need to:

- avoid hampering the economic and technological development or international co-operation in the field of peaceful nuclear activities;
- respect health, safety, physical protection and other security provisions as well as the rights of individual, and ;
- take every precaution to protect commercial, technological and industrial secrets.

In addition, in safeguarding a continuous spent fuel encapsulation process followed by the final disposal, after which nuclear material will be no more accessible for re-verification, timely performance is of particular importance.

5 Description of final disposal in Finland

5.1 General description

There are two nuclear power utilities in Finland at present. The Olkiluoto nuclear power plant consists of two BWR reactors, whereas the Loviisa nuclear power plant has two reactors of VVER 440 type. In addition, the VTT has a research reactor, FiR 1, of Triga Mk II type in Espoo.

Approximately 75 tonnes of spent fuel are annually removed from the reactors of the Olkiluoto and Loviisa NPPs and stored in wet storage facilities at the power plants. A total inventory of some 2600 tonnes of spent fuel will accumulate during the projected 40 years of operation of the Finnish reactor units.

In May 1999, Posiva, the company engaged in the final disposal submitted an application for a decision–in–principle to the State Council about the siting of the final repository near the Olkiluoto power plant in Eurajoki. The decision–in–principle on the location of the final repository was made by the end of 2000. This was followed by ratification of the Parliament in May 2001. Detailed investigations will be performed in 2000–2010 and the construction of the encapsulation plant will take place in 2010–2020. The disposal of spent fuel will start in 2020.

5.2 Time schedule

The design of the encapsulation plant is underway and expected to be available by the end of 2003. An indicative time schedule is given in Figure 2.

Construction of the “Onkalo”, an underground rock characterization facility aimed at site confirmation investigations, will start at Olkiluoto site by 2004. Note may be taken that the encapsulation and the transfer of the canisters into the final underground repository are planned to be a continuous process. The “Onkalo” can be expected to form a part of the final repository. Therefore a submission of the formal Design Information to IAEA as early as 2004 is desirable.

The following generic activities are required in order to develop and implement cost-effective and efficient safeguards at the conditioning plant: In-

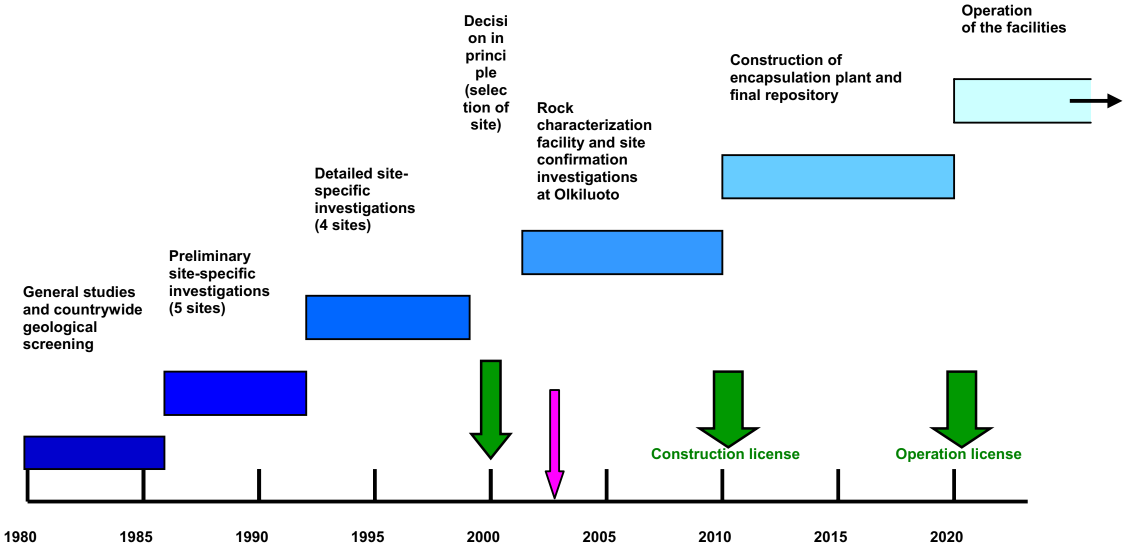

Figure 2. Overall schedule of the Finnish final disposal project and timing of the work.

troduction of safeguards relevant aspects into the design of the encapsulation plant;

1. Development of general regulatory requirements;
2. Identification and development of the measurement methods and techniques for the measurement station;
3. Identification and initiation of the development of reliable monitoring, containment and surveillance systems;
4. Identification and initiation of the development of the information and communication technological requirements, infrastructure and software tools;
5. Generation of the Technical Characteristics and the Design Information to the Euratom and the IAEA;
6. Development by IAEA of the safeguards approach, including identification of functional specifications and technical requirements;
7. Development and negotiation of the co-operation arrangements, communication and other procedures;
8. Provision of final design information, including the site definition, interim storage design, conditioning plant design and repository design.

Experience has shown that the development of reliable instrumentation for safeguards requires time. It is advisable to identify the technological options, as early as possible, and to continue with the development keeping in sight the date such equipment will be used.

5.3 Disposal process

The final disposal facility, including the encapsulation plant and the final repository of spent fuel, will be located at Olkiluoto. In this safeguards concept development, the reference encapsulation plant is an independent facility on the final disposal site. The plant will receive spent fuel in casks from both nuclear power plants, Olkiluoto and Loviisa.

The elements of the fuel cycle that are used as a basis for the development of this safeguards concept are schematically described below in Figure 3.

5.3.1 Shipping facilities

The spent fuel assemblies are stored in the reactor building for 1–3 years before they are transferred to the interim wet storage located at the nuclear power plant. Spent fuel is allowed to cool down for

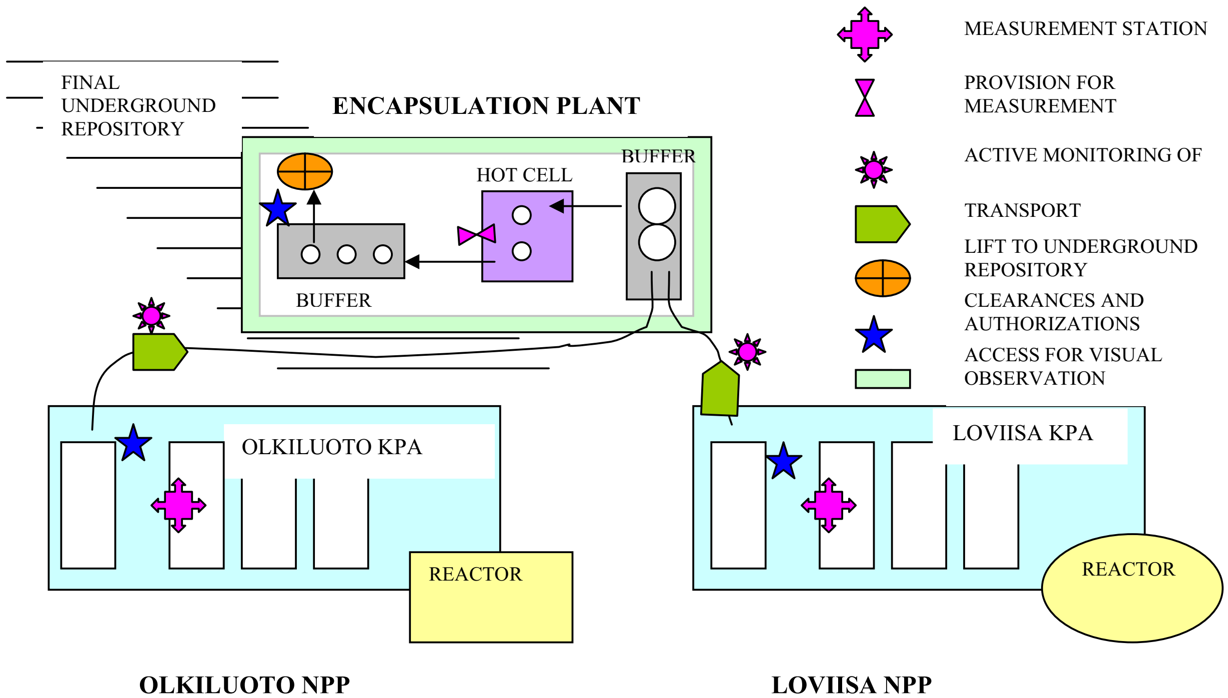

Figure 3. A schematic description of the final disposal of spent fuel from Olkiluoto NPP and Loviisa NPP in Finland.

20–40 years in the interim storage. The cooling is required to facilitate the encapsulation and final disposal process and for fulfilling the temperature and thermal-power generation limitations set forth to the canister for safety reasons.

The first operation to start the disposal process is the transfer of spent fuel assemblies from the interim wet storage to a wet characterization and verification station. This area provides for:

- Storage positions for spent fuel assemblies subject to shipment for final disposal;
- Characterization and verification station for final measurements of the spent fuel assemblies and other nuclear material containing items, if any;
- Buffer storage for spent fuel assemblies that have been characterized and verified and subject to clearance by the safeguarding authorities;
- Buffer storage for those assemblies, which have not passed the verification measurement;
- Shipping area to prepare for the transportation to the conditioning plant.

The spent fuel assemblies, storage and shipping containers at the shipping facilities, the Nuclear Power Stations at Loviisa and Olkiluoto, are subject to IAEA conventional nuclear material accountancy verification measures, including the use of containment and surveillance measures.

In this concept, the safeguards responsibility will be transferred to Posiva upon shipment of the spent fuel from these facilities to the encapsulation plant.

5.3.2 Shipment to encapsulation plant

Fuel transport from the interim stores of the nuclear power stations to the encapsulation pant will take place in the Castor type casks.

The capacity of the casks used by the Olkiluoto NPP is 50 BWR fuel assemblies. The plan is to use only 48 being a multiple of 12 that is the capacity of a single fuel canister. The casks filled with water and fuel are transported with the existing trailer to the encapsulation plant that locates within the private industrial area.

From the Loviisa plant, the fuel is transported in CASTOR VVER-440 type casks, which has capacity of 84 PWR fuel assemblies. The casks filled with water and fuel are transported to the encapsulation either by sea, by train or by truck, or with any combination of these. The fuel is transported, most frequently, once a month in two casks. Also, existing transport casks for 30 fuel assemblies may be used. The type of the cask used will be decided before the final design of the encapsulation plant.

5.3.3 Encapsulation process

In the encapsulation plant, the spent fuel is received and treated for final disposal. In the hot cell, the spent fuel assemblies are unloaded from the spent fuel transport casks, dried in an autoclave and loaded into the final disposal canisters. The gas atmosphere of the disposal canister is changed, the inner lid is closed, and the electron beam welding method is used to close the lid of the outer copper canister. The final disposal canisters are cleaned and transferred into the buffer store after the machining and inspection of the copper lid welds. From the buffer store, the final disposal canisters are transferred into the final repository vaults by the canister lift. All needed operations are performed safely and without any activity releases. The encapsulation operation is planned to be a continuous one.

The preliminary design of the spent fuel conditioning plant includes the following areas:

- Spent fuel receiving and storage area;
- Transfer corridor of the canisters;
- Spent fuel handling cell where fuel is placed in canisters;
- Welding station where the copper lid is welded;
- Inspection corridor and places for decontamination and unique identification of the canister;
- Buffer storage for 12 canisters ready for final disposal;
- Lift to lower canister down to the underground repository.

More information about the preliminary design of the encapsulation plant and process is provided in the Phase I report to this Task [1] and, particularly, in report [3].

The planned operational capacity of the plant is 60 canisters per year. The conditioning plant capacity can be raised to 100 canisters in a year if needed. This means that the plant will produce up to 2 canisters per one week containing 24 spent fuel assemblies.

5.3.4 Transfer to final repository

The fuel canister will be transferred in vertical position from the canister buffer store onto the canister lift trolley. The weight of the canister is about 25 tons and the weight of the trolley is about 5 tons totaling 30 tons.

The canister lift trolley is driven in the lift car with the fuel canister on it. At the final repository level, the canister is driven out to the canister docking station, where canister transfer vehicle can pick up the fuel canister.

6 Safeguards concept development

6.1 Objectives

The goals to guide the concept development are defined as following the results of the SAGOR work [8]. The implementation of safeguards system functions and associated evaluations shall provide credible assurance to all Parties engaged in the implementation that:

1. Diversion of spent fuel rods, assemblies, casks and canisters is not accomplished without early detection of indications or indicators of such diversion;
2. Spent fuel subject to final disposal is well characterized, accounted for and tracked;
3. Facilities, including reactors, encapsulation plant and final repository are operated as designed and declared;
4. Data and information generated is disseminated to the Parties who need to know, and stored in a secure way;
5. Knowledge created by the Parties, including the judgement and decisions taken, are maintained, and stored in a secure way;
6. Interference with the encapsulation plant operations is minimized;
7. Presence, frequency and intensity of the Euratom and IAEA activities at the encapsulation plant are kept to the minimum consistent with the objective of cost-effective safeguards.

The first goal relates directly to the technical objective of IAEA safeguards, to the timely detection of diversion of significant quantities of nuclear material and to the deterrence of such diversion by the risk of early detection.

The following three goals refer to the implementation strategy that emphasizes the importance of correct and accurate data and information as well as verification that leaves no doubt among the Parties about the nuclear material content, number and identity of items. The fifth point emphasizes knowledge creation, timely analysis and evaluation of the results and findings as well as importance of consequent judgement by the responsible Parties and their decision-making.

The last two points refer to the cost-effective operation of the encapsulation plant, to the cooperation in implementation and to the effective and efficient application of all measures available to IAEA safeguards.

6.2 Special features

The following specific features are taken into account while developing the preliminary concept for the Encapsulation Plant at Olkiluoto:

- Physical layout and processes are transparent, accessible for visual observation and instrumental presence to observe and monitor the flow of action, items and areas of interest to safeguards.
- Scheduling of activities and timing of communications, including findings of the FIN-SSAC and the Euratom, respectively, will permit coordinated conduct of the Parties in their functional responsibilities.
- Canisters produced in the encapsulation can be identified on the basis of unique number that will be difficult to falsify. The unique identification e.g. by use of patterns created in welding the lid may prove to be ineffective. Sealing of the inner lid could be considered.
- Process will be so structured that the encapsulation of spent fuel assemblies can continue without interruption. Should any irregularity be identified during the quality control actions pertinent to the process, corrective actions will be so organized that the maintenance of the continuity of knowledge is assured.

- Fuel assemblies become difficult to access when they are placed in a disposal canister. Once closed and sealed, canisters shall not be reopened for re-verification of their nuclear material content. Reopening is technically possible. For safety and security reasons, reopening of canisters cannot be excluded. When spent fuel is emplaced in the repository, it will no longer be accessible for direct safeguards verification.
- Results of the earlier verification measures and the evidence of the successful maintenance of the continuity of knowledge shall be made available to provide for credible assurance that the spent fuel assemblies and other material subject to encapsulation and transfer to final repository is as declared.

7 Preliminary safeguards concept

7.1 Conditions

The following conditions are assumed and taken into account when developing the safeguards concept for the encapsulation plant in Olkiluoto:

1. The spent fuel assemblies received at the encapsulation plant are characterized, accounted for and verified at the wet interim storage prior to shipment to the plant.

2. The encapsulation plant is considered as a 'book inventory area' for the material balance accountancy purposes. The nuclear material is not made routinely available for re-verification. The nuclear material inventory at any given time is established through monitoring the material flows and through measures to maintain the knowledge.

3. Physical layout of the conditioning plant will be transparent. The design of the plant, its layout and processes are such that visual, human observation and instrumental monitoring are facilitated. Other required access can be managed through particular procedure that will be agreed in advance.

4. Timing of nuclear material handling and other services as well as the verification and clarification activities of those engaged in safeguards implementation are organized in a way that the encapsulation of spent fuel assemblies can be carried out as a continuous process.

5. Documentation and communication systems ensure that authentic information about identity of items subject to safeguards, their nuclear material content and other operational and circumstantial information relevant to safeguards are made timely available to all Parties responsible for safety, safeguards and security and, as appropriate, to those responsible of societal functions.

6. Institutional presence in the form of periodic inspections, unannounced inspections and complementary access and design information review visits will play major role in verification of the declared operations and in assuring the absence of any undeclared nuclear activities and materials. Services and processes will be scheduled so that adequate time will be made available for the organizations to carry out their activities appropriately.

7. Establishment and maintenance of a comprehensive and correct database, a coherent set of information and creation and maintenance of a knowledge base relevant to safeguarding the final disposal is of fundamental importance for all Parties engaged in the implementation. The institutional conclusions will be based on the documented up–to–date, well-maintained data-, information and knowledge bases.

8 Maintenance of the continuity of knowledge is not limited to that associated traditionally with the use of seals and surveillance on items or areas containing nuclear material subject to safeguards. Knowledge to be maintained in institutional memories includes all safeguards relevant data and information and their use as premises, as factual or circumstantial evidences, in the argumentation aimed at drawing conclusions and deciding follow-up actions.

9. Parties implementing safeguards system functions are willing, able and capable to analyze and evaluate timely the results of their activities and all other information so as to make it possible to draw the conclusions and communicate these in timely manner.

10. In case satisfactory clarifications cannot be obtained without re-verification of the nuclear material content of the assembly or that of the canister, these will be returned back to a position where the required reassurances can be obtained. After such a case a review will be carried out to understand why the Parties could not implement their responsibilities in a timely and effective manner. Such consideration shall also address the responsibilities associated with the additional costs and other consequences.

7.2 Measurement station

Measurement for the characterization and verification of all spent fuel subject to encapsulation and transfer to the final repository is the cornerstone of the final disposal safeguards system. It is suggested that this measurement should take place already in the nuclear power plants, in their wet interim storage facilities.

It is important that the final verification of nuclear material is carried out in good time before the assembly goes into the encapsulation phase. When required, the safeguards authorities would have time to respond to the verification results or results of any complementary activities before the assemblies are subjected to encapsulation into the final disposal canister.

Should there be a bigger problem at one of the supplying sites the process could be switched into conditioning of spent fuel from the other supplying nuclear power plant. This possibility would facilitate the continuous operation of the conditioning plant on one hand and the clarification of the open issues on the other hand.

Especially maintenance operations of the verification station or a finding of an irregular case would not interrupt the whole conditioning and disposal process. This would save time and facilitate the maintenance of cost-effectiveness of the disposal process.

The measurement should be capable to rod level verification. This means that the measurement should be able to distinguish dummy assemblies from spent fuel and, additionally, all dummy or missing rods should be detected in a spent fuel assembly. On the present state–of–the–art level of NDA measurement technology only the Passive High-Energy Gamma Emission Tomography (PHEGET) can comply with this requirement. Further development of the method is required, however.

After the characterization and verification of spent fuel assemblies the primary function of the safeguards system is to maintain the continuity of knowledge; generate and document the relevant data and information as well as create the knowledge required for the decision making about compliance.

The assemblies that have been characterized and verified by all Parties as a joint activity shall stay about one month in the buffer storage allowing time for institutional evaluation and decision making—spent fuel assemblies are ready for transport and waiting for institutional clearances.

Upon receipt of the clearances the assemblies in that batch are released for transportation to the conditioning plant. The safeguards responsibility will be transferred from the Nuclear Power Plants to Posiva, which is the company responsible for the final disposal.

7.3 Shipment to encapsulation plant

During the shipment, transportation and receipt at the encapsulation plant appropriate human and instrumental presence of the Parties is ensured by optimal combination of inspections, complementary access visits and use of monitoring, containment and surveillance measures.

The transport casks are sealed and maintained under continuous surveillance and monitoring regarding their condition and location. Transports are conducted under instrumental monitoring and institutional observation. Technical means and communication technology to monitor the shipments is understood to exist and to be in routine use.

The shipments will be scheduled so that cost-effective conduct becomes possible. The SSAC personnel are present and inspectors from Euratom and the IAEA may decide to verify the operations, and to carry out inspections and complementary access activities.

7.4 Encapsulation process

Encapsulation is a continuous process beginning with the receipt of the spent fuel transport and storage container and ending with the shipment of the disposal canisters by a lift down to the final repository.

7.4.1 Receipt and handling

Spent fuel arrives at the conditioning facility in casks under seals and surveillance. Operator of the Encapsulation Plant accepts the receipt of the spent fuel assemblies on the basis of the shipper's values. The spent fuel received at the Plant would be placed in the buffer store for received spent fuel casks.

The spent fuel cask is prepared for docking and moved on rails to the docking station under the hot cell. Two separate docking stations are available for the different types of transport casks. The cask is sealed into the hot cell docking penetration. The internal covering hatch of the hot cell is opened, and the radiation protection lid of the spent fuel cask is lifted inside the hot cell. The fuel assemblies will be lifted one by one with the fuel-handling machine into the autoclave for drying. The operation is monitored by camera.

7.4.2 Loading of the spent fuel canister in the hot cell

A new, empty canister is, in principle, received, stored and prepared in the same way as the spent fuel transport cask. Each canister, cast iron insert and lid has a unique ID number stamped. For reading the ID numbers the hot cell has cameras connected to a computer equipped with character recognition software. The computer has the access to the accountancy data base for registering the ID numbers of the canisters, lids and every fuel assembly.

The knowledge base provides access to the required information about the nuclear material content and other required characteristics, including those pertinent to safety.

The operations in the hot cell are monitored and documented by the camera, including the closing of the inner lid of the fuel canister.

Leaking assemblies are special cases, and their capsules are not opened at the Conditioning Plant. The capsules containing a leaking fuel assembly will be handled in the same way as the fuel assemblies themselves. Specially designed canisters will be manufactured for these capsules. An infrequent special campaign is envisaged for these operations.

Provision for the fuel assembly measurement is embedded in the floor of the hot cell like the autoclaves. It is shielded from the radiation of the open spent fuel cask and other sources so that accurate measurements can be carried out when required. Note should be taken that the current design does not foresee any routine nuclear material verification in the hot cell. Therefore no installed measurement instrumentation is foreseen either in the current design or in this safeguards concept.

Fuel assemblies could be diverted from the hot cell through the ceiling trap door into the decontamination area. In addition to the visual access and camera monitoring of the hot cell operations, the radiation monitoring of the hot cell ceiling trap door is required.

7.4.3 Closing of the canister and quality control inspections

After tightening the inner lid and testing its tightness, the canister will be moved to the transfer corridor. The ID number of the copper lid is registered and the lid is installed. This operation is carried out under camera surveillance.

The canister is moved to the electron beam welding. After welding the seam is machined and the weld inspected by ultrasound and by X-ray. The welding operation can be visually monitored through a lead glass and by camera that is installed in the vacuum chamber. An X-ray inspection produces a unique image of the welded seam of the canister, and it may be used as a "fingerprint" identifier, which can be registered and saved in the accountancy data base. Further research is required, however.

7.4.4 Canister disassembly in case of rejected welds

If the canister does not pass the quality inspection, it will be returned to the welding station for repair of the weld. If the weld cannot be repaired, the canister will be returned to the encapsulation line and the weld will be removed by cutting. The canister will be connected to the docking station of the hot cell and the fuel removed.

After removing the fuel assemblies, the canister can be used as a waste package for high active waste. The outer copper lid can be recycled. The opening and rejection of the canister and the removal of the fuel are registered in the accountancy data base, after which a new canister is introduced and the removed fuel batch is loaded into as described in Sec. 7.4.2.

7.4.5 Handling of new canisters in hot cell

A new canister is brought to the encapsulation by truck. In the Encapsulation Plant, the canister is lifted by crane from the truck and lowered into the canister transfer corridor with its supporting frame. The canister is then positioned on a remote-controlled track-wheeled transfer trolley. All canister fittings are transported together with the canister. The support is returned back to the workshop.

When the new canister is loaded onto the trolley, the operating personnel can be in situ for the manual operations and controls.

A canister on a trolley, also the one loaded with the spent fuel, can be taken out from the transfer corridor by the use of the canister lift. Therefore, for safeguards purposes, radiation monitoring is required at the lift entrance door.

7.5 Handling of ready fuel canisters

7.5.1 Transfer into the buffer store

After the canister has passed inspections, the accepted canisters will be transferred into the canister buffer store for waiting to be transferred into the final repository. The cost-effective operation of the Plant does not foresee any static inventory in the buffer store. Should there be a need, for safeguards purposes, to operate in a batch mode it will have cost implications. Therefore possibility to implement safeguards adequately on the continuous process must be further studied with care.

7.5.2 Transfer to repository

In case the Encapsulation Plant is attached to the Olkiluoto KPA store, the loaded fuel canister is transported to the entrance building of the final repository on the road about 2 km, like any spent fuel containers. Equal safeguards provisions would be applicable to such transfers. The operations in the entrance building housing the lift to final repository are expected to be similar to those for case where the Encapsulation Plant is an independent facility.

In case the Encapsulation Plant is an independent facility, the fuel canister will be transferred in vertical position through a labyrinth from the buffer store onto the canister lift trolley. The canister is moved by the trolley to the lift that takes it to the underground repository.

The canister ID number is read by the camera and registered into the accountancy data base, when the fuel canister is transferred from the buffer store to the canister lift. The radiation level in the lift entrance room is measured, when the canister is loaded onto the canister transfer trolley.

The payload of the canister lift including the lift car is minimized. The weight of the fuel canister is about 25 tons and the weight of the trolley about 5 tons totaling 30 tons. Possible role of weight monitoring in safeguards by use of load-cells could be studied.

At the final repository level, the canister is driven out to the canister docking station, where the canister transfer vehicle will pick up the fuel canister.

7.6 Process monitoring and control

The monitoring and control activities can be divided into production control, process control, safeguards monitoring, radiation monitoring, release monitoring and access control.

It is understood that the production and process monitoring and control activities can be used to serve safeguards purpose, particularly to facilitate complementary measures that are aimed at verifying the declared operations and detection of any undeclared nuclear materials and activities. The production and process control activities are primarily serving radiation and nuclear safety or security and societal purposes. The possible role in safeguards of the following should be studied more carefully.

- The use of the Encapsulation Plant control room functions and recordings also for the safeguards monitoring.
- The role of the process control corridor providing visual access to the hot cell and canister transfer corridor.
- Use of the ventilation system to monitor the atmospheric environment for safeguards purposes. The exhaust air activity is monitored continuously.
- Monitoring of the direct radiation continuously and on need to know basis. Monitoring of the contamination levels of various premises and materials.

- Monitoring the material transfers from the hot cell to the decontamination and the work in the area of decontamination.
- The bentonite block production is not supervised from the control room. However, the personnel transfers the blocks to the canister lift, which transfers them to the final repository. The operation is interfering with the handling of the canisters.
- Use of hot cell manipulators for collecting environmental samples for safeguards purposes.
- Use of the drainage water system for collecting environmental samples for safeguards purposes.
- Active waste produced by the encapsulation and decontamination will be stored in the final repository, in the cavern close to the canister shaft bottom. The canister lift will be used and the operation is interfering with the handling of the canisters.

The above activities are of interest to safeguards particularly when considering the complementary access regime aimed at assuring that no undeclared nuclear activities and materials are present at any given time within the site and facilities associated with the encapsulation and final repository of spent fuel. Therefore it may be prudent to connect the automatic process control and radiation monitoring systems into the accountancy data base for registering all significant or exceptional events detected by the process control or radiation monitoring systems.

It is understood that, due to the accessible process design and continuous well-defined and clean production, the process and production control activities could play a significant role in safeguards implementation and in its cost-effectiveness.

8 Conclusions

The planning, site characterization investigations and the design of the final disposal facilities, including the Encapsulation Plant and the final underground repository, have advanced to the point where also safeguards requirements shall be considered.

The Operator, Posiva Oy, has made available documents [4] and [5] describing the encapsulation process, the buildings and the relevant services. During the year 2004, the Operator is planning to begin with the construction of the first underground site investigation shafts and galleries, which probably will form a part of the final repository. The authorities responsible for regulatory control, including safeguards, are invited to contribute to the design of these processes and facilities.

The preliminary safeguards concept developed under this Support Programme task for the Encapsulation Plant is based on the above referred documents and the assumption that integrated safeguards will be implemented in Finland in 2–3 years. The general experience gained in implementing IAEA strengthened safeguards measures suggests that the optimal use of all measures available to the IAEA system, including those of the Additional Protocol, is possible and that effective safeguards can be implemented by the Parties in Finland. Enhanced role of the Finnish national safeguards system and improved cooperation between the IAEA and Euratom is expected to ensure the cost-effectiveness.

The proposed safeguards concept is based on requirement that the encapsulation will be a continuous, clean and transparent process. In which only well-characterized and previously verified items will be handled. The final accountancy verification of spent fuel assemblies should take place at the shipping facilities. No nuclear material verification measurements are planned to take place at the Encapsulation Plant. However, a structural provision for the NDA measurements in the hot cell will be prepared. This means that the continuity of knowledge will play a central and particular role in the development of safeguards conclusions and maintenance of the management confidence about full compliance with the safeguards agreement obligations. Authentic measurement results and other findings during storage, transportation and handling will be made timely available by FIN-SSAC through secure communications to all Parties who need to know. The continuity of knowledge about the identity and content of the spent fuel in the assemblies and of the canisters to be disposed will be maintained. Optimum combination of inspections, use of monitoring, containment and surveillance technology as well as complementary access and DIV visits will make it possible for the Parties to draw their respective conclusions with confidence.

It is suggested that the concept is technically feasible and can be implemented with the cooperation of all parties. However, as suggested in the attached ANNEX, further research and development effort is required in order to apply the proposed concept. This effort includes identification of the measurement and monitoring technology and its further development to support the application.

The proposed safeguards concept means a challenge to the organizations, to their analysis and evaluation processes as well as to the knowledge creation, the decision making and follow-up action. In order to support an effective instrumental presence and institutional access, appropriate information and communication technology shall be identified and application developed. Further development in the area of the cooperation arrangements and implementation procedures is also required.

State-level evaluation of the compliance is the undertaking of the IAEA. Emphasis is by now at establishment and maintenance of conditions that enable it to draw credible conclusions of the absence of undeclared nuclear activities and materials and of the absence of diversion of declared nuclear materials. Cost-effectiveness of that system rests upon a reliable and effective national system that is capable to provide timely, correct and complete declarations and able to respond to any questions that may arise in implementation. The Euratom system is expected to provide its contributions timely to the system implementation, and as agreed.

The security is based on knowledge, information and data is not enough. The national system, on one hand, generates and disseminates, through secure channels, the required information and data to parties who need to know. On the other hand, it maintains the knowledge base that transparently and coherently represents all nuclear activities and materials associated with the final disposal of spent fuel in the Finnish bedrock—thus enabling effective implementation of the IAEA safeguards also for the back end of the fuel cycle in Finland.

The concept described shall be subject to a critical consideration by all Parties. The objective of such considerations is to define the research and development needs and to find out ultimately optimal ways and means to implement safeguards at the final disposal of the spent fuel in Finland cost-effectively. As a result the IAEA should be able to conclude, in a timely and credible manner, about the full compliance by Finland with the Safeguards Agreement and the Additional Protocol.

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ANNEX Technical feasibility of concept for safeguarding the spent fuel encapsulation plant in Finland

1 Safety and safeguards requirements

In order to meet both safety and safeguards objectives accurate information must be available on need–to–know basis about the nuclear material, including information about identities of items and quantities of the nuclear material handled in the disposal process. The disposal process is schematically depicted in Figure A-1.

The amount and flow of nuclear material has to be controlled in the viewpoint of both safety and safeguards. The amount of fissile material has to be controlled to ensure criticality safety. The transfer casks, storages, handling devices and disposal canisters of spent fuel assemblies have to be designed in a way to prevent critical fuel concentrations in all situations. [1, 2]

The total thermal load of a disposal canister is restricted because the temperature of the bentonite buffer in the repository has to be kept under 100°C to ensure its chemical stability. The optimum assembly combination in each disposal canister can be achieved by mixing assemblies with cooling time about 40 years and assemblies with cooling time about 20 years. [3] The radiation dose rate outside the disposal canister has to be minimized. Because of that, the assemblies with high burnup should be placed into the central positions in the disposal canister. The restricted thermal load of the disposal canister and the minimization requirement of the radiation dose rate outside the canister set limits regarding the set of assemblies to be disposed of in a certain disposal canister.

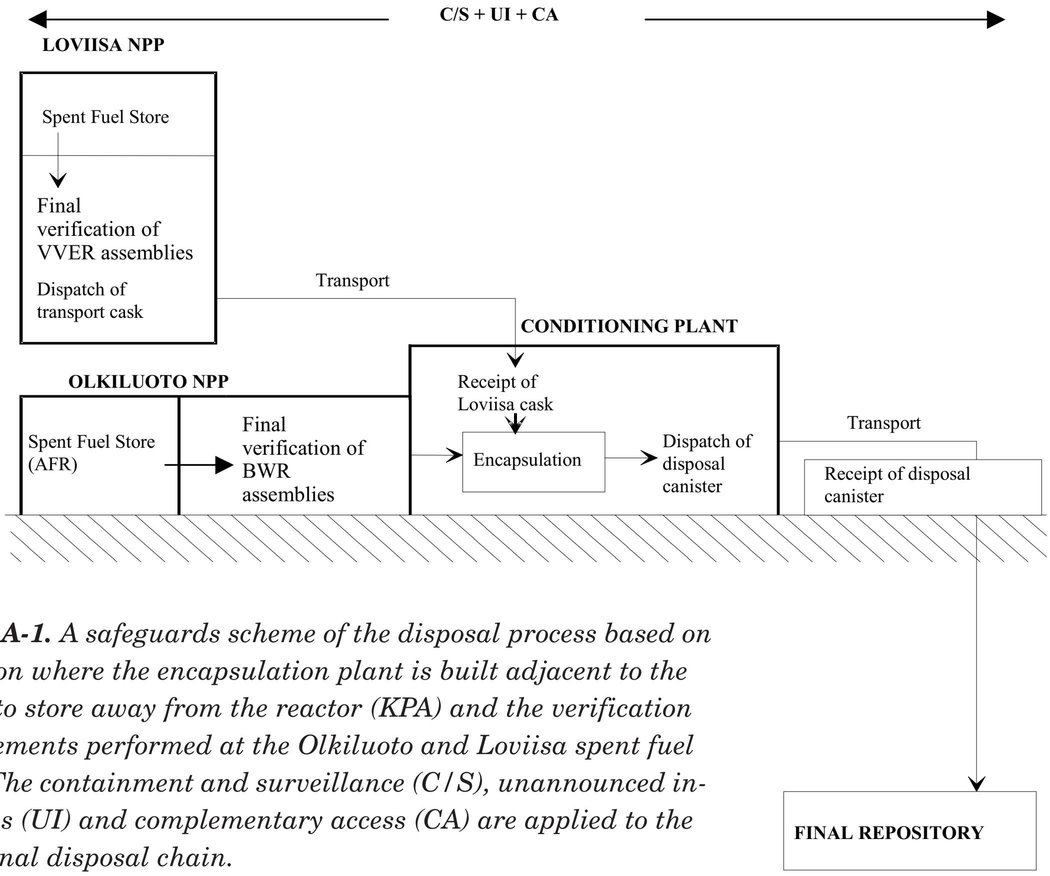

__Figure A-1.__ A safeguards scheme of the disposal process based on the option where the encapsulation plant is built adjacent to the Olkiluoto store away from the reactor (KPA) and the verification measurements performed at the Olkiluoto and Loviisa spent fuel stores. The containment and surveillance (C/S), unannounced inspections (UI) and complementary access (CA) are applied to the whole final disposal chain.

These conditions imply that each shipping of assemblies to the encapsulation plant should be planned well in advance. An annual plan, quarterly and monthly updates can be envisioned to facilitate also safeguards implementation, including advance notification about the accountancy verification campaigns at the wet interim storages of the Nuclear Power Plants.

2 Design aspects of final characterisation and verification

No general safeguards approach exists for the final disposal facility. Until the final disposal a permanent feature of the nuclear material under safeguards is that it always can be re-verified when needed. This feature does not apply for the final disposal. The nuclear material will no more be available for safeguards verification purposes after its disposal into the final repository.

A verification measurement station is the cornerstone of the final disposal safeguards system. The safeguards concept foresees a requirement of rod level verification, i.e. the measurement should be able to distinguish each rod in the assembly and, additionally, to be able to distinguish an irradiated spent fuel rod from a dummy. After the verification the function of the safeguards is to maintain the continuity of knowledge. In planning the safeguards system, the aim is that the whole disposal process would be optimized to be safe, effective and efficient. Owing to that the final verification measurement station should be integrated to serve the disposal process as a whole.

The final disposal facility consists of an encapsulation plant and an underground repository. They will be designed concurrently. Posiva has started to design two encapsulation plant options. Depending on the design, the encapsulation plant either is associated with the wet interim storage facility of the Olkiluoto NPP (Olkiluoto KPA Store) or will be constructed apart from the KPA Store. In the latter option the encapsulation plant would be attached to the repository. The preferred design will be selected as the basis of further work. [4, 5]

2.1 Verification gate

The most practical and possibly also the most economical option seems to be to build the verification station in both interim storage facilities (Figure A-1). Both the BWR and the VVER assemblies could be verified at their present site and MBA. This option would, however, require setting up two final verification systems for the assemblies.

If the encapsulation plant were built adjacent to the Olkiluoto KPA Store, the encapsulation plant and the KPA Store would form a building complex with an interim storage part and an encapsulation part. For the verified BWR assemblies to be disposed of, there would be one transfer route from the interim storage to the encapsulation part of the complex. The only possible way to transfer the assemblies from the KPA Store to the encapsulation plant would be through the strategic point i.e. the verification gate. Only the regular cases would pass the verification gate and be moved on to the encapsulation plant.

Correspondingly the VVER assemblies could be verified at the interim storage of the Loviisa NPP (Loviisa KPA Store), where another verification gate should be built between the storage area and the shipment terminal. The verified fuel assemblies could be loaded directly into the shipping containers, which could be sealed and stored temporarily to wait for the transportation to the encapsulation plant.

2.2 Verification measurements in water

The verification measurements and all handling operations related to the measurements could be performed in water. The present experience on all types of underwater measurements subjected to spent fuel is far more extensive than the experience on corresponding measurements in air. The water would give radiation protection for the persons involved in the disposal process. No heavy radiation shields would have to be built. Because water absorbs radiation originating from other spent fuel assemblies the only requirement is that the verification gate should be far enough from them. Water also attenuates impacts should accidents or mishandling of assemblies happen, e.g. dropping of an assembly.

2.3 Regular and irregular cases

If the assembly passes the verification measurement, it is called a “regular” assembly, and it will be placed into a buffer storage designated exclusively for the verified regular assemblies. The buffer storage could be e.g. a transport cask. In the buffer storage a verified batch destined to certain disposal canisters will be collected for the next shipment. Only the regular spent fuel assemblies would be transported to the encapsulation plant.

The potentially irregular cases make additional demands for the verification process. The irregularities would have to be solved in an effective and efficient way. The irregular cases cannot pass the gate and be transferred to the encapsulation plant. This would call for a storage place specially designated for these assemblies. The storage for irregular cases might be arranged in a specific rack in one of the storage ponds. Safeguards plans have to take into consideration how, where and when the irregularities would be solved. A substitutive assembly should be found for the irregular assembly. To minimise the interruptions in the disposal process a buffer storage for substitutive assemblies would be essential in the interim storage. The substitutive assemblies must have been verified earlier to be regular. Additionally, the residual power limitations, as discussed in Sec. 1, must be observed when choosing a substitutive assembly for an irregular one.

2.4 Effective and efficient disposal process

The verification measurements could be performed at the KPA Store in parallel with the encapsulation operations at the encapsulation plant. When one batch is in the encapsulation process, the next batch could be in the verification process. Especially maintenance operations of the verification station or a finding of an irregular case would not interrupt the whole disposal process. This would save time and make the whole disposal process more effective and efficient. It is also very important from the safeguards point of view to perform the final verification in good time before the assembly goes into the encapsulation phase.

The regular assemblies would be stored in a buffer storage for one month before the shipment for encapsulation. When needed, the safeguards authorities would have one month of time to respond to the verification results of the assemblies before their shipment into the encapsulation plant.

3 Maintaining the continuity of knowledge

After the final verification a reliable C/S system would be needed to maintain the continuity of knowledge. This system would include instrumental presence and institutional action in situ.

After closing and sealing at the encapsulation plant, reopening of a disposal canister for safeguards purposes will not be allowed. The continuity of knowledge would be ensured with overlapping systems with different operation principles. The failure of one system should not lead to a broken continuity of knowledge. In the safeguards point of view one of the key issues is that the C/S system should be capable of preserving the continuity of knowledge in all situations. This would imply that information about any failure, or possible failure, in the system function would reach the Party who need to know in a timely manner.

Decontamination processes and handling of empty canisters as well as radioactive waste generated in the disposal process should be safeguarded. Credible assurance that spent fuel is not diverted through the various handling routes or among the waste should be obtained.

In addition to safeguards controls, the operator’s monitoring and control systems, aimed at production control, process control, radiation monitoring, release and dose control and access control, could be of use also for safeguards purposes. These activities could be used to facilitate complementary measures that are aimed at confirming the declared operations and at making possible early detection of indications of any undeclared nuclear materials and activities.

The production and process control activities primarily serve radiation and nuclear safety or security and societal purposes. Their possible role in safeguards should be studied more carefully. The present technology allows a fully automated computerized C/S system, which checks the seals for tampering attempts, records the ID number of the transport cask, reads and records the ID number of each assembly to be unloaded from the transport cask and subsequently loaded into the disposal canister. Also the ID number of the disposal canister and its lids can be registered. This system could be connected into the accountancy database. A basic tool of the C/S system would be an event register, which would register all events equipped with their date and time stamps. Every event would trigger a due recording in the material accountancy database. All recordings of the process and radiation monitoring systems could also be stored in the event register. Also all events recorded in the physical protection and security system could be registered in this event register. Should there be any need to track the events afterwards, all events would be available for solving any question whether it regards a technical problem in the process, a safety problem or any question regarding the safeguards or physical protection of the facility.

4 Conclusion

Based on the presented contemplation, the final verification station in the Olkiluoto KPA store and in Loviisa respectively seems to be a feasible option. The C/S and monitoring technology to support the maintenance of the established knowledge is understood to be available. The same can be stated about the information and communication technology. However, in addition to identification, further development work is required to ensure effective application and implementation.

At this stage, the following particular issues are identified for further consideration:

- Measurement station and required NDA technology to be applied at Olkiluoto and Loviisa KPA Stores.
- C/S and monitoring technology to control transportation of the spent fuel assemblies.
- The use of the encapsulation plant control room functions and recordings also for the safeguards monitoring, particularly to monitor the encapsulation process.
- The role and use of the process control corridor providing visual access to the hot cell and canister transfer corridor.
- Use of the exhaust air monitoring system for safeguards purposes.
- Monitoring of the contamination of various premises and materials and monitoring of the direct radiation at strategic points like the lift entrance to the underground repository.
- Monitoring the material transfers from the hot cell to the decontamination and monitoring the work in the area of decontamination.
- Monitoring of the bentonite block production, which is not supervised from the control room. The personnel transfer the blocks to the canister lift. These transfers to the final repository are interfering with the handling of the canisters.
- The role of weight monitoring should be investigated.
- Use of hot cell manipulators for collecting environmental samples for safeguards purposes from the hot cell structure and equipment.
- Use of the drainage water system for collecting environmental samples for safeguards purposes.
- Monitoring the radioactive waste produced by the encapsulation and decontamination. The radioactive waste will be stored in the final repository, in the cavern close to the canister shaft bottom. The canister lift will be used and the operation is interfering with the handling of the canisters.
- Connection of the process, safety, security control systems and the safeguards C/S systems into a common event register. The register would be available for all Parties involved for tracking of any event or any sequence of events, which might have significance in assuring on the maintenance of the safeguards objectives or solving any question raised by any Party.

The above listed activities are of interest to safeguards, some of them particularly when considering the complementary access regime aimed at assuring that no undeclared nuclear activities and materials are present at any given time within the site and facilities associated with the encapsulation and final repository of spent fuel.

In addition, cooperation and coordination shall be supported with the appropriate technology and procedures to facilitate data and information collection and distribution, knowledge creation and sharing on need to know basis. Further work is required to identify and develop the required applications.

5 Future issues

Research and development activities concerning the final disposal of spent nuclear fuel in Finland are continued at the Olkiluoto site after the Decision in Principle made by the Government of Finland in December 2000 and ratified by the Parliament of Finland in May 2001.

Posiva is expected to present a detailed description of the final disposal facility at the end of 2003. The encapsulation plant design approach, whether attached to the interim storage or to the final disposal site, will have influence on the safeguards plans. The technical plan for arranging the nuclear material safeguards has to be included in the detailed encapsulation plant designs.

According to Posiva's schedule the application for construction permit should be submitted in 2010. Then the technical plan for arranging the nuclear material safeguards has to be complete. This emphasises importance of integrating the safeguards planning to the overall disposal facility planning. Because Posiva will begin with the site characterisation investigations, including the construction of an underground shaft, the 'Onkalo', already in 2004, the planning and required development work also in the safeguards area is due.

Posiva and Swedish Nuclear Fuel and Waste Management Company (SKB) have agreed to cooperate in the research and technology field of the final disposal of spent fuel. The goal of both companies is the final disposal of spent fuel in the bedrock. Posiva and SKB can optimise their activities by cooperating and by exchanging information. Expenses can be cut down by avoiding overlapping operations. Cooperation between Posiva and SKB might optimise also the design work of the safeguards system. Both safeguards systems will probably have common features, which could be implemented in the same way even if the encapsulation plant will be individual in each country. Cooperation may be also a trap hole in some sense. Should the schedule of either Posiva or SKB be drawn out, it could jeopardise also the schedule of the other partner.

The requirements of the safeguards are under development. The most economical solution to implement the safeguards system in the year 2020 is by maintaining the design of the safeguards system up-to-date to meet the developments through regular updates until the final disposal starts. The aim is that the whole disposal process is optimised to be safe, effective and efficient. [6]

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